Report

What Is Driving the Environmental Behavior of Manufacturing Plants in Semarang? Implications for Policy-Makers

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REPORT

WHAT IS DRIVING THE ENVIRONMENTAL BEHAVIOR OF MANUFACTURING PLANTS IN SEMARANG? IMPLICATIONS FOR POLICY-MAKERS

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List of Acronyms

AMDAL	Environmental impact assessment document
BAPEDAL	Indonesia's national environmental impact agency
BAPEDALDA	Local (regional, provincial, or city level environmental impact agencies
BAPPENAS	Indonesia's national planning agency
OECF	Japanese Organization for Economic Cooperation and Finance
PROKASIH	A clean rivers program managed by BAPEDAL
PROPER	An environmental business rating program managed by BAPEDAL
REPILITA	Indonesia's five year plans produced by BAPPENAS
WALHI	Umbrella NGO for environmental NGOs in Indonesia

Executive Summary

Relatively little is known about the impact of local regulatory actions and local community pressure on the environmental behavior of manufacturing plants in developing countries. Even less is known about the impact of environmental market pressures on the polluting behavior of manufacturing plants in developing countries. This paper is designed to address these lacunae by reporting the results of a recent survey of the environmental behavior of 121 manufacturing plants in a large industrial city (Semarang) on the north coast of Java in Indonesia. The survey was designed to identify the scope of plant level environmental behaviors; measure the extent of exposure of sampled plants to regulatory, community and market pressures and to government fiscal/financial incentives; and assess the impact of each of these on plants' environmental behavior.

A complete data set was collected for 110 plants. Of these plants, 31 (28%) were chemical plants, 28 (25%) were textile plants, 26 (24%) were food and beverage plants, while the rest 25 (23%) were in other industries. The average plant in the sample employed 322 people, was 16.3 years old, and had annual sales of Rp. 146 billion. Forty percent (44 plants) of these plants stated that they had made pollution control expenditures between 1991 and 1996. Annual expenditures for pollution control averaged Rp. 35.3 million. Thirty-six percent of the surveyed plants stated that they self monitor emissions, 17% stated that they reported self monitoring results to the local BAPEDALDA, while 21% reported that they had at least a nascent plant level environmental management system (EMS).

The overall exposure of these plants to regulatory, community, and public pressure was quite high. Fully 84% of the plants have been subject to government monitoring and/or warnings by government. Fully 72% of the plants have been exposed to community pressure (CP). Significantly fewer firms (16%) have been exposed to pressure from buyers (BP). Twelve percent of the plants had received financial assistance from government (DFA) to help then install pollution control equipment.

A model developed by Pargal and Wheeler (1996) was adapted to statistically ascertain the impact of plant characteristics (size of plant, age of plant, productivity of plant, sector of plant), regulatory actions, community and environmental market pressure, and government financial assistance on plants' environmental behavior. Statistical findings show that plant characteristics, regulatory actions, community and market pressures, and financial assistance all influence whether or not a plant invests in pollution control, whether or not it engages in several other internal environmental management practices, and the extent of those practices. Despite this, statistical findings also show that regulatory actions and community and market pressures exert no influence on differences among plants in levels of pollution abatement.

This raises an interesting question. Why do regulatory, community, market pressure, and financial assistance exert statistical influence on the probability that a plant will invest in pollution control; the probability that it will engage in internal environmental management practices, and on the extent of those practices, but not on the amount of pollution abatement plants undertake?

While no definitive answer to this question is provided, one interpretation is that these pressures are sufficient enough to encourage plants to engage in some level of environmental

management as a way of demonstrating to concerned regulators, communities, and buyers that they take their environmental concerns seriously. But they are not sufficient for plants to base actual abatement behavior on them.

Several important implications flow from these findings. The "good news" is that plants in Semarang do respond to regulatory, community and market pressures, and government financial assistance. This leads them to invest in some abatement; to engage in some internal environmental management practices; to do some self-monitoring of emissions; and to occasionally report the results of self-monitoring to BAPEDALDA, Semarang. This has three salutary effects. It provides an opportunity for plants to learn how to control pollution prior to being forced to do so. It signals to plants that the time is coming when they will have to undertake significant abatement. And it provides an opportunity for BAPEDALDA, Semarang to learn about pollution and polluters in Semarang.

But these findings also show that real, significant abatement of pollution in Semarang has not yet occurred. Sixty percent of the plants in our sample have not invested in pollution control. Of those that have, the mean level of expenditures as a percent of plant sales is very close to zero. Correcting this almost assuredly depends on developing more effective regulatory actions. This includes more systematic and reliable monitoring of emissions. And it includes development of effective sanctions which can be used to force reluctant polluters to comply with emissions standards. It might also depend on developing a regulatory strategy which builds on nascent community and market pressures on polluters.

I. Introduction

Relatively little is known about the impact of local regulatory actions and local community pressure on the environmental behavior of manufacturing plants in developing countries.[1] Even less is known about the impact of environmental market pressures on the polluting behavior of manufacturing plants in developing countries.[2] This paper is designed to address these lacunae by reporting the results of a recent survey of the environmental behavior of manufacturing plants in a large industrial city (Semarang) on the north coast of Java in Indonesia. Research methodology included in-depth interviews in Semarang in November and December of 1997 and use of a rapid appraisal survey instrument that was administered to a sample of manufacturing plants in December 1997 and January 1998. The survey instrument was designed to collect basic information on manufacturing plants; identify the scope of plant level environmental behaviors; and assess the extent of exposure of sampled plants to regulatory, community and market pressures, and government financial assistance designed to get plants to install pollution control equipment. Data from the survey was used to test hypotheses about the relationships between environmental behaviors, on the one hand, and characteristics of plants, and exposure to regulatory actions, community and market pressures, and government financial assistance on the other hand.

To anticipate findings, the survey evidence reveals significant environmental behaviors by manufacturing plants in Semarang and equally significant exposure to regulatory, community and market pressures, and to access and use of government financial assistance. Econometric evidence suggests that these pressures (and financial assistance), including traditional regulatory actions by the local environmental agency, had significant impacts on the environmental behaviors of manufacturing plants in Semarang.[3] This indicates that even a weak local environmental agency without the authority to monitor and enforce emissions standards can promote plant behaviors which favor the environment. But findings also suggest that much remains to be done if local environmental quality is to be improved.[4]

Discussion of these issues is organized into five sections. Section II describes the evolution of environmental law, policy, and regulation in Indonesia and Semarang. Section III describes the data used for hypothesis testing. Section IV presents a simple model for testing hypotheses about plant level environmental behaviors and reports statistical results. Section V summarizes findings and draws conclusions.

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1. Several statistical studies (Pargal and Wheeler, 1996; Hettige, Huq, Pargal, and Wheeler, 1996, Aden, Ang, and Rock, 1998; and Mani, Pargal, and Huq, 1997) relying on national or state level data of either emissions or abatement show that environmental behavior is affected by plant characteristics, community pressure, and regulatory actions. But as far as we know, there are no empirical studies that focus on what happens at the local level. Because effective monitoring and enforcement is almost always a local issue, this is unfortunate.

2. There are lots of anecdotes of environmental market pressure, but as far as we know, no one has tested for it.

3. Particularly on whether or not a plant invested in pollution control; on whether or not it engaged in any other internal environmental management practices; and on the extent of those practices.

4. We come to this conclusion because we could find no evidence that regulatory, community, or environmental market pressures exerted any influence on the level of a plant's abatement expenditures.

2. The Evolution of Environmental Law, Policy, and Regulation

Compared to most developing countries, Indonesia has established an enviable record of concern for the environment. This began with the government's preparations for the UN sponsored Conference on the Living Environment in Stockholm in 1972.[5] Following this, the government established a Committee for Formulation of Environmental Policy headed by the Vice Chair of Indonesia's powerful national planning agency, BAPPENAS. And it established the first of what were to become 54 university-based Environmental Study Centers (PSLs) designed to increase the skills capacity in Indonesia to tackle environmental problems (World Bank, 1994: 183). Subsequently, the government's third five-year plan (REPILITA) stated that the environment should be protected from undue damage. At about the same time, the Ministry of Industry issued a directive calling on the country's manufacturers to avoid and overcome the environmental pollution associated with industrial growth (Cribb, 1990: 1126).[6] In 1978, the government established a Ministry of State for Development Supervision and the Environment and appointed a widely respected "technocrat" as Minister. In 1983 the government created a cabinet-level State Ministry for Population and the Environment.

These institutional changes were accompanied by the promulgation of equally important environmental regulations and laws that set the stage for more effective environmental management. In 1982, the government passed landmark environmental legislation, the Act Concerning Basic Provisions for the Management of the Living Environment. This act institutionalized requirements for environmental impact assessments, or AMDALs; empowered the Ministry of State for Population and the Environment to co-ordinate environmental policy at the cabinet level; granted provincial governors executive power over environmental matters within provinces; and opened the way for development of new quality standards for protecting the environment (O'Connor, 1994:71).[7] The act was quite explicit about who was responsible for cleaning up pollution. It stated, in part, that

> "whosoever damages and/or pollutes the living environment is liable for payment of compensation to victims whose rights to a good and healthy environment have been violated...and whosoever damages and/or pollutes the living environment is liable to the State for the costs of restoration... (Cribb, 1990: 1127)."

By 1985 the government had successfully educated Indonesians about the need to protect the environment.[8] It had gone a long way toward creating a skills base for better environmental

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5. Unless otherwise noted, what follows is drawn from World Bank, 1994: 179-81.

6. The 1978 Ministry of Industry directive on "Prevention and Handling of Environmental Pollution from Industry" established, in principle, an environmental impact requirement for new industries (O'Connor, 1994: 7).

7. However, the Act did not create the legal basis for the environmental ministry to set emissions standards and monitor and enforce them.

8. For example, a survey of adults in four major cities in 1992 revealed that 84% of those surveyed felt that Indonesia faced serious environmental problems (World Bank, 1994: 177).

management.[9] And it had built public support, through environmental NGOs, for government actions to protect the environment.[10]

Despite all of this, it was clear that Indonesia had not yet put in place the machinery for legally monitoring and enforcing the country's tough emissions standards. This began to change in 1986 when the government announced Regulation 29 outlining the steps required for carrying out environmental impact assessments (AMDALs) for new industry (World Bank, 1994: 269). Following this a substantial number of environmental impact assessments were completed (O'Connor, 1994: 97). Subsequently, the State Ministry for Population and the Environment launched an innovative "voluntary" pollution reduction program (PROKASIH) in collaboration with the Ministry of Home Affairs and senior officials from provincial governments.[11] In 1990, the President decreed the creation of an environmental impact management agency, BAPEDAL, with responsibility for implementing the country's environmental laws and regulations. This agency took over responsibility for environmental impact assessment (AMDALs) and PROKASIH, and launched its own creative monitoring and enforcement program (PROPER) (Afsah and Vincent, 1997).

Following the creation of BAPEDAL, the government invested heavily in "growing" it into an efficient command and control environmental regulatory agency. BAPEDAL was (and is) one of the few, perhaps the only central government agency, assigned an senior civil servant dedicated to "growing" the agency. Since its founding, staff has increased from approximately 30 in 1990 to almost 500 in 1996, while BAPEDAL's budget has increased to RP. 29.2 billion in 1997.

BAPEDAL also receives significant support from the donor community. The World Bank supports a legal mandate project, a traditional enforcement and compliance program, and a regional institutional development program. The objective of the first is to create a legal basis for BAPEDAL to monitor and enforce emissions standards. The second is aimed at increasing the capacity of BAPEDAL to successfully monitor and enforce, while the objective of the third is to support development and capacity building of local (regional) monitoring and enforcement agencies (BAPEDALDA). Other donor support includes a regional monitoring capacity development program with OECF, an ADB regional network development program, an Australian aid program for upgrading laboratories, an OECF pollution abatement equipment soft loan program, and a Canadian funded Collaborative Environmental Protection in Indonesia program. In addition, the Americans and the Danes have provided pollution prevention assistance. Because of all of this, technical capacity in BAPEDAL is steadily improving.

9. By 1995, many of the country's Environmental Studies Centers (PSLs) routinely provided substantial technical assistance for AMDALs. This does not mean that the AMDAL process is without problems (World Bank, 1994: 269-273).

10. Discussion of this can be found in Cribb (1990).

11. The PROKASIH (Clean Rivers) Program was designed to reduce pollution loads from major water polluters along 24 of the country's most polluted rivers. Technical coordination was provided by KLH. Administrative coordination was provided by the Ministry of Home Affairs. Implementation was carried out by provincial authorities who worked with Prokasih Teams to identify major polluters, encourage firms to commit in writing to voluntarily reducing pollution loads by 50% within a specified time frame, monitor performance relative to targets, and increase pressure on those not making good faith efforts to meet their commitments (World Bank, 1994: 133).

BAPEDAL has also gone a long way toward creation of provincial level environmental management offices (BAPEDALDA). Fully sixteen BAPEDALDA were established by the Ministry of Home Affairs in 1996 and 1997. Interestingly enough, BAPEDALDA, Semarang predates the central government's creation of regional environmental agencies. It emerged in the midst of a highly publicized pollution case.[12] n this case, rice and fish farmers, located downstream from industrial firms in an industrial estate, suffered substantial losses to their livelihoods following pollution of the stream used for irrigation, fish-farming and drinking water. The farmers sought help from the Indonesian Legal Aid Society and from WALHI, the country's umbrella organization for environmental NGOs. Both the national environmental impact agency, BAPEDAL, and the government of Semarang city got involved in negotiating a pollution control agreement with the offending firms. Following this, the city of Semarang established its own BAPEDALDA and empowered it to monitor plant level emissions. Since then, BAPELDALDA, Semarang has been engaged in a low level monitoring and enforcement program.

What has this all added up to? Is there any evidence that firms in Indonesia or Semarang are abating pollution or that ambient environmental indicators are improving? Unfortunately, it is not easy to answer these questions. The biggest problem is that direct and regular collection of field level data on ambient environmental indicators is still quite limited.[13] Regular monitoring of water quality is carried out in relatively few areas.[14] The same can be said about monitoring of air quality even in major urban areas.[15] These problems are compounded by a general lack of quality control in data collection and in laboratory analysis; by the use of outdated and inadequate laboratory equipment; by a shortage of well-trained staff; and by a lack of standardized protocols for monitoring and analyzing data samples.[16] As a recent World Bank (1994: 175) report states, these shortcomings represent a major handicap to the design of cost-effective environmental policies.

In addition, BAPEDAL's legal mandate for monitoring and enforcement remains weak. Only representatives from the Ministry of Industry and Trade have the authority to enter plants to monitor waste emissions. BAPEDAL also lacks the legal right to enforce emissions standards and it is not allowed to bring charges against polluters in the country's courts. This leaves enforcement in the hands of local police. To make matters worse, provincial governors have the responsibility for monitoring ambient environmental quality and for monitoring plant level emissions, but for the most part, they lack the resources and technical capacity to do this well.[17]

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12. This case is discussed in World Bank (1994: 202-203).

13. Currently, BAPADALDA, Semarang does not monitor any ambient environmental indicators.

14. But, it should be noted, available evidence suggests that water quality is poor and probably deteriorating. For example, water quality at the intake of the Kali Surabaya treatment plant was considered sub-standard for 80% of the samples taken and bacteriological quality has been deteriorating since 1984. Similarly, tap water samples in Jakarta in 1992 revealed a 73% rate of coliform contamination (World Bank, 1994: 69)..

15. As with water quality, available evidence suggests that ambient air quality is poor and deteriorating (World Bank, 1994: 72-73).

16. BAPEDALDA, Semarang suffers from all of these problems.

17. This is also the case for BAPEDALDA, Semarang. Because of this, the local environmental agency's enforcement actions are currently limited to issuing warning letters.

All of this has led BAPEDAL to search for creative ways to attack some of the country's worst ambient environmental quality problems. To date, this has meant focusing on major polluters of freshwater along the country's major rivers. Two of these programs, the PROKASIH (Clean Rivers) Program and PROPER, an environmental business rating program, have shown some progress in reducing water effluent emissions from major polluters (Afsah and Vincent, 1997).

3. The Survey Data

The picture presented above is a mixed one. On the one hand, the Government of Indonesia has taken important steps to develop the capacity to monitor and enforce the country's tough emissions standards. Much of the legal and institutional framework is now or soon will be in place. Despite the lack of clear legal authority to monitor and enforce the country's emissions standards, the environmental impact agency, BAPEDAL, has engaged in several creative and innovative approaches to monitoring emissions and enforcing emissions standards that work. Government investments in university-based Environmental Study Centers have, without a doubt, expanded the capacity of Indonesians to analyze environmental problems. The country's investments in environmental NGO building have also paid off.

But clearly all is not well. A weak legal mandate to monitor and enforce has been combined with equally weak local (regional) environmental impact agencies (BAPEDALDA). These agencies, including BAPEDALDA, Semarang, suffer all of the problems afflicting BAPEDAL and they have even fewer resources and less technical capacity. This overall picture suggests that the regional agencies may be involved in little monitoring and even less enforcement. If this is the case, pollution abatement and other environmental behaviors by manufacturing plants may be either poor or non-existent unless they are countered by community and/or market pressures or are included in one of BAPEDAL's innovative programs.

To gain a clearer sense of the scope of manufacturing plant level environmental behaviors in Indonesia and the factors affecting them, we undertook a survey of 121 manufacturing plants in four high polluting sectors (chemicals, food and beverages, textiles, and other (primarily wood processing) in Semarang city. The purposes of the survey were to document the scope of plant level environmental behavior; measure the exposure of plants in Semarang to regulatory, community and market pressures, and access to government financial assistance for installing pollution control equipment. We also wanted to assess the impact of each of these on plants' environmental behaviors. A complete data set was collected for 110 plants. Of these plants, 31 (28%) were chemical plants, 28 (25%) were textile plants, 26 (24%) were food and beverage plants, while the rest 25 (23%) were in other industries. The average plant in the sample employed 322 people, was 16.3 years old, and had annual sales of Rp. 146 billion. Forty percent (44 plants) of these plants stated that they had made pollution control expenditures between 1991 and 1996. Annual expenditures for pollution control averaged Rp. 35.3 million. Thirty-six percent of the surveyed plants stated that they self monitor emissions, 17% stated that they reported self monitoring results to the local BAPEDALDA, while 21% reported that they had at least a nascent plant level environmental management system (EMS).[18]

The overall exposure of these plants to regulatory, community, and public pressure was quite high. Fully 84% of the plants have been subject to government monitoring and/or warnings by government. Fully 72% of the plants have been exposed to community pressure (CP). Significantly fewer firms (16%) have been exposed to pressure from buyers. Twelve percent of the plants have received financial assistance from government to help then install pollution control equipment.

18. Plants with nascent EMS systems stated that they either had environmental staff, engaged in environmental audits, or had quantitative pollution reduction goals.

Not surprisingly, these averages hide significant sectoral differences. While there was not much difference in the average age of plants across sectors (Table 1), the average textile plant had more employees (662) and more sales (Rp. 464 billion) than either chemical plants (which averaged 171 employees and annual sales of Rp. 110 billion), food and beverage plants (which averaged 154 employees and annual sales of Rp. 2.09 billion) and plants in the "other" category (which averaged 303 employees and annual sales of Rp. 12.2 billion).

What do we know about the level of exposure of these plants to regulatory, community and market pressures? We answered this question by constructing a number of indices of plant level exposure to each of these. With respect to regulatory pressure we were interested in a plant's exposure to an intensity of government monitoring/sanctions variable. Design of questions to capture this were based on actual experiences in Semarang and suggestions in Ayres and Braithwaite (1992: 35-39) that regulation works best when regulators have at their disposal a hierarchy of monitoring and sanctions strategies. Since BAPEDALDA, Semarang has only a limited number of options for monitoring and enforcing emissions standards, we developed a measure of government monitoring/sanctions that captured this by creating a composite monitoring/sanctions index, labeled (GMW) as follows:[19]

GMW	=	FGM + 2*WN where
FGM	=	the frequency of government monitoring over the past twelve months and
WN	=	the number of warning letters the plant received over the past twelve months

A plant's exposure to community pressure (CP) was captured by weighting and summing answers to questions designed to assess awareness at plants to others' exposure to community pressure (weight=1) and the plant's direct exposure to community pressure (weight=2).[20] A plant's exposure to environmental market (buyer) pressure (BP) was captured by weighting and summing answers to questions designed to measure the awareness at plants to others' exposure to environmental pressure from buyers (BP) (weight=1) and the plant's direct exposure to pressure from buyers (weight=2).[21]

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19. Sanctions are limited to issuing warning letters. These can come from the mayor, provincial governor, local district official (bupati), or from the local environmental agency.

20. This was done by weighting and summing answers (Yes =1, No =0) to the following questions: Have you observed other plants in Semarang (or has your plant been) being exposed to pollution complaints by neighbors? Have you observed neighbors requesting other plants to reduce pollution (or has your plant been asked by neighbors to reduce pollution)? Have you observed other plants (or has your plant negotiated) negotiating pollution control agreements with neighbors?

21. This was done by weighting and summing answers (Yes =1, No =0) to the following questions: Do you know if buyers are imposing environmental considerations on other plants (or your plant) in Semarang? Have you observed buyers (or have your buyers) introducing(ed) environmental requirements on purchases from them (you)? Have you observed or are you aware of buyers asking others (or you) whether you are in compliance? Have you observed or are you aware of buyers offering help to others (or you) to meet emissions standards? Have you observed or are you aware of buyers imposing pressure on others (or you) to meet emissions standards?

Table 1
Descriptive Statistics by Sector

	Chemicals		Textiles		Food & Bev.	
	Mean	Std.	Mean	Std.	Mean	Std.
DIN	.58	.50	.25	.44	.31	.47
DEN	3.0	2.87	1.35	2.43	1.53	2.4
DEMS	.35	.49	.18	.39	.12	.33
PCE	24E+6	59E+6	46E+6	22E+7	46E+6	9E+6
EMP	171	341	662	879	154	296
AGE	16.2	11.1	15.0	10.0	15.3	10.4
S/E	67E+7	32E+8	17E+7	63E+8	13E+6	1E+7
GMW	6.22	4.9	6.89	7.0	6.58	9.89
DFA	.09	.30	.18	.39	.03	.20
CP	2.06	1.8	1.96	1.59	2.23	1.9
BP	.42	.95	.29	.66	.15	.54

1. DIN = dummy variable (1,0) for installation of PCE
2. DEN = sum of dummy variables (1,0) for DIN, self monitoring, report self monitoring to BAPEDALDA, servicing its pollution control equipment, and DEMS (whether the plant has environmental staff, commissions environmental audits, or has quantitative pollution reduction goals).
3. PCE = annual average expenditures for pollution control.
4. EMP = number of employees
5. AGE = age of plant in years
6. S/E = plant level sales per employee in rupiah
7. GMW = as defined on p. 14.
8. DFA = 1 if plant receives government financial assistance and DFA = 0 otherwise.
9. CP = as defined on p. 14.
10. BP = as defined om p. 14.

The overall plant level exposure to regulatory, community, and public pressure is quite high. Fully 84% of the plants have been subject to monitoring/warnings. Given BAPEDALDA, Semarang's limited resources and its lack of a legal mandate to monitor and enforce, this finding is quite surprising.. Overall exposure to community pressure is also quite high. Fully 72% of the plants have been exposed to community pressure (CP). While we do not have a full explanation for this high level of exposure to community pressure, it may well reflect the publicity surrounding a highly charged pollution case of several years ago.[22] Finally, it should be noted that significantly fewer firms (16%) have been exposed to pressure from buyers (BP).

Not surprisingly, exposure to each of these "pressures" varies by sector. Ninety-seven percent of textile plants have been exposed to government monitoring/warnings. The comparable figures are 94% for chemical plants, 90% for food and beverage plants, and 76% for plants in the "other" category. Seventy-six percent of the textile plants have been exposed to community pressure, while 74% of the chemical plants, 80% of the food and beverage plants, and 60% of those in the "other" category have been so exposed. With respect to environmental pressure from buyers, 18% of the textile plants have been exposed to such pressure, while 22% of chemical plants, 10% of food and beverage plants, and 16% of plants in the "other" category have been exposed to buyer pressure.

22. As mentioned earlier, in this case plants in an industrial estate in Semarang emitted pollutants into a river that flowed into the Java Sea killing shrimp/fish in a large number of fish-ponds on the north coast of Java just outside Semarang. The farmers complained to the mayor of Semarang. The Indonesian Legal Aid Society brought a suit against the polluters and WALHI, the umbrella organization for environmental NGOs in Indonesia, threatened to organize a consumer boycott against the products produced in the plants in the industrial estate thought to be responsible for the pollution. In this highly celebrated case, the mayor of Semarang, BAPEDAL, the firms involved, and the villagers negotiated a settlement in which the offending firms paid compensation for damage done and reduced pollution from the industrial estate by installing waster water treatment facilities (World Bank, 1994: 202).

4. Statistical Tests

The survey data suggest that this sample of manufacturing plants in Semarang engages in significant environmental behavior, and is subject to substantial regulatory, community, and buyer pressure. This made it possible to formally test hypotheses regarding the impact of regulatory, community, and market pressures (and provision of financial support) on plant level environmental behaviors.[23] The approach to hypothesis testing is to first look directly at a range of environmental behaviors of plants in Semarang. We ask whether or not plants invest in pollution abatement. Among plants that invest in abatement, we ask why some invest more than others. This gives us two separate dependent variables: one is a simple dummy variable (DIN = 1 if a plant has installed pollution control equipment between 1991-1996 and DIN = 0 otherwise); the other is the average annual pollution control expenditures between 1991-1996 (PCE). We examine several other aspects of a plant's environmental behavior. We ask, in a series of questions, whether or not plants engage in one of three environmental management practices. From this, we created a dummy variable (DEMS = 1 if the plant has any environmental staff, commissions environmental audits, or has quantitative pollution reduction targets and DEMS = 0 otherwise). Finally, we constructed a "count" dependent variable (DEN) that simply added up dummy variable (1,0) scores on eight other dummy variables.[24] By focusing on these specific plant level environmental behaviors, we are asking how plants have responded with specific environmental actions to regulatory, community, and market pressures.[25]

Because characteristics of plants (size, age of plant, productivity, ownership and industrial sector of plant) have been shown to affect a plant's environmental behavior (Hettige, Huq, Pargal, and Wheeler, 1996), we included measures of these variables in our statistical analysis. More specifically, we hypothesized that because large plants are more visible than small plants, they should engage in more environmental behaviors than small plants. Because more productive plants have more resources to engage in a wider range of environmental behaviors, we expect them to engage in more

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23. Statistical tests were based on a model developed by Pargal and Wheeler (1996). They model the polluting behavior of plants as the equilibrium outcome of a plant's demand for environmental services (the right to pollute) and a community's willingness to supply those services (accept pollution). This requires treating the demand for environmental services as a derived demand for another factor of production. Because of this, they model a plant's demand for environmental services as a function of the " implicit" price of pollution (the expected penalty or compensation demanded by communities), output prices, other input prices, and a set of characteristics of plants (size, age, ownership, and productivity). They model the willingness of a community to accept pollution (or emissions) from a particular plant as a function of community bargaining power vis a vis polluters, community income, the damage imposed on the community by pollution, and a plant's economic attractiveness to a community. Modeling emissions this way permits them to use ordinary least squares (OLS) to estimate reduced form emissions demand curves.

24. Those variables consisted of (Yes = 1, No = 0) answers to the following questions. Have you installed pollution control equipment? Have you installed it to cover pollution from the whole plant? Do you service this equipment? Do you self-monitor emissions? Do you report the results of self-monitoring to local environmental authorities? Do you have any environmental staff? Have you commissioned any environmental audits? Do have you quantitative pollution reduction goals?

25. That is, our testing of the Pargal and Wheeler model assumes that regulators, communities, and buyers pressure plants to clean up and that government's can encourage plants to invest in pollution control by offering fiscal and financial incentives to them.. Because of this, a plant's environmental behavior reflects regulatory, community, and market bargaining power vis a vis plants and the implicit valuation by regulators, communities,
and markets of the damage done by not reducing pollution. Following Pargal and Wheeler, an individual plant's supply of a cleaner environment (its environmental behavior) is treated as the outcome of regulatory actions and community and buyer pressures. That is, faced with increasing pressure (a rising implicit price of pollution) to change environmental behavior, plants respond, all other things being equal by changing their environmental behavior.

of these than small plants. Because foreign owned plants are likely to be more vulnerable to criticisms from communities and scrutiny from regulators than domestically owned plants and because they may follow environmental practices of their home countries, they are expected to do more than domestically owned plants.[26] Because plants differ by sector in their pollution intensities, we also expect sector of plant to affect environmental behavior.

We estimated multiple regression equations of the following type where ENVBEH represents one of four different environmental behaviors.[27]

ENVBEH = f(EMP, AGE, S/E, GMW, CP, BP, CH, T, FB) where

Behavior 1:

DIN = 1 if a plant installed pollution control equipment and DIN = 0 otherwise

Behavior 2:

DEMS = 1 if a plant engages in any of three environmental management practices and DEMS = 0 otherwise

Behavior 3:

DEN = a count of the number of times a plant engages in any of the following behaviors DIN = (1, 0), DINWPLT = 1 if pollution abatement equipment covers the whole plan and DINWPLT = 0 otherwise, DEMS = (1,0) DSM = 1 if a plant self monitors emissions and DSM = 0 otherwise, DRSMB = 1 if a plant reports self monitoring results to BAPEDALDA and DRSMB = 0 otherwise, and DSER = 1 if the plant services its pollution control equipment and DSER = 0 otherwise.

Behavior 4:

PCE = the value (in rupiah) of average annual pollution control expenditures between 1991- 96.

Dependent variables included in these regression equations include characteristics of plants, measures of regulatory actions, measures of community and market pressures, and a measure of

26. Because there were so few plants in the sample with foreign ownership, we were unable to use this variable in any of the regressions.

27. Following Pargal and Wheeler (1996), we estimate reduced form demand curves for plant level environmental behavior.

whether or not a plant received fiscal/financial assistance to install pollution control equipment.[28] Results of estimation appear in table 2.[29]

What did we find? Starting with whether or not a firm installed any pollution control equipment between 1991 and 1996 (DIN = 1 if a plant installed pollution control equipment and DIN = 0 otherwise), seven out of nine of our independent variables are statistically significant. This equation shows that the **probability** of a plant installing pollution control equipment is a positive function of plant size (EMP), age of plant (AGE), government monitoring/warning (GMW), community pressure (CP), and a plant's access to fiscal/financial incentives (DFA). Sector also matters. Chemical plants have a higher probability of investing in pollution control, while textile plants have a lower probability of investing in pollution control. Taken together, these seven variables accounted for roughly forty percent of the variation in the probability of plants investing in pollution control. This equation correctly classified 82% of all plants.[30]

With respect to estimation of the probability that a plant is engaged in internal environmental management practices (DEMS = 1 if it is engaged in those practices and DEMS = 0 otherwise), five of the independent variables are statistically significant. The DEMS regression equation shows that the probability of a plant engaging in internal environmental management practices is a positive function of plant size (EMP), government monitoring/warning (GMW) , community pressure (CP), and buyer pressure (BP). In addition, chemical (CH) and food and beverage (FB) plants have a higher probability of engaging in internal environmental management practices, while textile (T) plants have a lower probability of engaging in such practices. Taken together, these seven variables account for about one-half of the differences among plants in EMS practices. This equation correctly classifies 96% of all plants.

28. Plant characteristics include: plant size (EMP = number of employees); age of the plant (AGE = number of years since the plant was built); productivity of plants (S/E = annual sales (in rupiah) per employee); and ownership of the plant (OWN = 1 if the plant is domestically owned and OWN = 0 for any level of foreign ownership). Measures of regulatory actions, community pressure, market pressure, and fiscal financial assistance include GMW (the previously defined government monitoring/sanctions variable); DFA (the previously defined fiscal/financial assistance dummy variable); CP (the previously defined community pressure variable); and BP (the previously defined buyer pressure variable). Taken together, the variables in equation 1 above permit estimation of the impact of plant characteristics, regulatory actions, community and market pressures, and government fiscal/financial assistance on plant level environmental behavior.

29. Because three of our dependent variables (DIN, EMS, and DEN) are not continuous variables, estimation by ordinary least squares (OLS) is not appropriate. For the binary (1,0) dummy dependent variables (DIN and EMS), we used a probit estimation technique (Johnston and DiNardo, 1997: 419-424). For the "count" variable dependent variable (DEN), we used a count regression technique (Gourieroux, Monfort, and Trognon, 1984). For the continuous dependent variable (PCE), estimation was by ordinary least squares (OLS). Results of estimation appear in table 2 above. In addition to reporting regression coefficients, t tests, and adjusted R^2s, reported results include pseudo R^2s (or goodness of fit tests) for the non-continuous dependent variables (DIN, EMS, and DEN). We also report test results for heteroskedasticity and specification error. Neither appear to be a problem. Nevertheless, where appropriate, (in the OLS estimation of the PCE equation, White's heteroskedasticity-consistent standard errors are reported. Three final comments about estimation deserve mention. Where possible, estimation was of the log-log type. Since so few plants in the sample had any foreign ownership, the OWN variable is not reported in any equation in table 2. Since our crude productivity variable (S/E) was not significant in any equation, it is not included in regressions reported in table 2.

30. Classification was based on the assumption that if the predicted probability of investing in PCE was greater than .5, plants were classified in the category DIN =1, while if the predicted probability of investing in PCE was less than .5, plants were classified in the category DIN = 0.

Turning to regression estimation of the count dependent variable DEN, results show that again seven of the independent variables are statistically significant.[31] The count variable, DEN, is positively affected by plant size (EMP), government monitoring/warnings (GMW), community pressure (CP), pressure from buyers (BP), and access to fiscal/financial incentives (DFA). In addition, chemical plants have higher count scores and textile plants have lower count scores. These variables account for about a third of the variation in the count variable.

Taken together, these three equations suggest that plant characteristics, regulatory, community and buyer pressure, and access to fiscal/financial incentives all exert significant influence on (a) the probability of a plant investing in pollution control; (b) on the probability of it engaging in internal environmental management practices, and (c) on the scope (count) of plant engagement in a wide range of environmental behaviors, including self monitoring emissions and reporting results of self monitoring to BAPEDALDA, Semarang.

However, when we considered the impact of this same set of independent variables on plants' levels of pollution control expenditures, results were surprisngly different. In the equation on log(PCE), only three plant characteristics, size (EMP) and sector (T and FB) were statistically significant.

31. Preliminary estimation on the count dependent variable (DEN) relied on a Poisson model, but tests for overdispersion and specification error led us to reject the Poisson restriction. This was replaced with a two step negative binomial quasi-generalized pseudo-maximum likelihood estimator suggested by Gourieroux, Monfort, and Trognon (1984).

Table 2
Regression Equations of the Determinants of Plant Level Environmental Behavior

	DIN	DEMS	DEN	log (PCE)
Const.	-4.27	-5.88	-2.39	1.12
Log (EMP)	.36 (2.60)***[32]	.53 (3.15)***	.27 (3.34)***	1.21 (4.15)***
log (AGE)	.50 (2.39)***	.08 (.38)	.23 (1.35)	-.25 (.42)
GMW	.05 (2.85)***	.03 (1.73)*	.03 (3.18)***	.04 (1.55)
DFA	1.12 (2.43)***	.52 (1.10)	.83 (3.75)***	.03 (.02)
CP	.2 (2.74)***	.38 (3.92)***	.18 (4.07)***	-.12 (.69)
BP	.09 (.61)	.47 (2.23)**	.12 (2.03)**	.03 (.10)
CH	.81 (2.14)***	1.58 (2.64)***	.81 (3.36)***	-.48 (.57)
T	-1.14 (2.38)***	-.14 (.23)	-.63 (1.82)*	2.30 (2.08)**
FB	.15 (.34)	.54 (.87)	.30 (.93)	-2.05 (2.17)**
$\bar{R}^2$	.39[33]	.46	.28[34]	.32
Spec. Test	.42[35]	.047	218.40[36]	.61

Those three characteristics of plants accounted for almost one-third of the variation in pollution control expenditures of plants. This provides powerful evidence that plant characteristics affect abatement behavior. More surprisingly, neither regulatory actions (GMW), community pressure (CP), buyer pressure (BP), nor fiscal/financial incentives (DFA) are statistically significant in this equation.

This raises an intriguing question. Why do the regulatory, community, and buyer pressure variables exert statistical influence on (DIN), the probability that a plant will make pollution control

32. ***indicates statistical significance at the .01 level, ** indicates significance at the .05 level, and * indicates significance at the .10 level.

33. Reported R^2 for this equation and the next (regression on EMS) is McFadden's pseudo R^2.

34. Reported R^2 is a likelihood ratio (pseudo R^2).

35. Specification test statistic for this equation and the next (regression on EMS) is an LM test.

36. Specification test statistic is an adjusted likelihood ratio statistic. For the PCE equation it is a Ramsey Reset test.

expenditures; on (DEMS), the probability that it will engage in internal environmental management practices; and on (DEN), the extent (count) of those practices, but not on the amount (log PCE) of a plant's abatement expenditures? We do not have a good answer to this question. It appears that these pressures have led manufacturing plants in Semarang to engage in some level of environmental management as a way of demonstrating to concerned regulators, communities, and buyers that they take their environmental concerns seriously. But since those pressures are in an early stage of development, plants are not taking them seriously enough to engage in substantial pollution abatement.

Several pieces of evidence are consistent with this interpretation. For one, relatively few plants have experienced direct community pressure (13%) or direct environmental pressure from buyers (2%). But many of the plants in our sample are aware of these pressures. This seems to have been sufficient to get these firms to install some, but not much pollution control equipment. On the other hand, a large percent of the plants in our sample have had emissions monitored by government and have received warnings from government when emissions exceed standards. But because government does not have the power to legally force a plant to clean up, direct experience with monitoring/warnings apparently has not encouraged plant's to engage in substantial abatement. Evidence of this can be seen by calculating the ratio of annual pollution control expenditures of a plant to its annual sales. Experience elsewhere shows, that once environmental regulations begin to take hold, annual pollution control expenditures can average about one-half of one percent of sales, sometimes even more (O'Connor, 1994: 181). In Semarang, both the mean and median values of pollution control expenditures as a percent of sales for those plants making any expenditures on pollution control are effectively zero! The maximum ratio of annual pollution control expenditures to annual sales for plants undertaking any pollution control expenditures is less than .01%.

5. Implications for Policy-Makers

What are the implications of our findings for those interested in getting manufacturing plants in Semarang to abate more pollution. Several are particularly notable. First, the “good news” is that plants in Semarang do respond to regulatory, community, and market pressures. This leads them to invest in some abatement; to engage in some internal environmental management practices; to do some self-monitoring of emissions; and to occasionally report the results of self-monitoring to BAPEDALDA, Semarang. This has three salutory effects. It provides an opportunity for plants to learn how to control pollution prior to being forced to do so. It signals to plants that the time is coming when they will have to undertake significant abatement. And it provides an opportunity for BAPEDALDA, Semarang to learn about pollution and polluters in Semarang.

But these findings also show that real significant abatement of pollution in Semarang has not yet occurred. Nearly two-thirds of the plants in our sample have not invested in any pollution control. Of those that have, the mean level of expenditures as a percent of plant sales is effectively zero. Correcting this almost assuredly depends on developing more effective regulatory actions. This includes more systematic and reliable monitoring of emissions. And it includes development of effective sanctions that can be used to force reluctant polluters to comply with emissions standards. Evidence from our own work on Korea (Aden, Ang, and Rock, 1998) shows that this can work. It might also depend on developing a regulatory strategy that builds on nascent community and market pressures on polluters. Evidence from several of BAPEDAL’s innovative regulatory programs suggest that this too can work (Afsah and Vincent, 1997).

This leaves at least one unanswered question: What can BAPEDALDA, Semarang do while the government establishes the legal basis for a tough monitoring and enforcement program and while BAPEDALDA, Semarang develops the capacity to manage a rigorous compliance program? There are three answers to this question. First, steps should be taken now to invest in capacity building to manage a tough monitoring and compliance program. This requires substantial investment in a laboratory for testing emissions. It requires substantial investment in training. Second, scarce regulatory resources should be funneled into high pay-off (in terms of pollution reduced) activities. Several are suggested by our findings. Larger firms are abating more than smaller firms. Working with these larger plants could well provide both quick returns and positive examples for others. BAPADALDA, Semarang might also consider building on nascent market (buyer) pressures to abate pollution. This might involve, for example, focusing regulatory efforts on plants producing name brand products, or on those plants that export, or on those associated with highly visible conglomerates. If this were combined with a public disclosure program such as the U.S. Toxics Release Inventory Program (Arora and Cason, 1995) or BAPEDAL’s PROPER program, it too could yield substantial returns. Finally, BAPADELDA, Semarang might consider using community pressure to assist it. Here too, much can be learned from PROPER.

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